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USSR Report

CONSTRUCTION AND EQUIPMENT

(FOUO 6/82)

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USSR REPORT

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CONSTRUCTION

EVALUATION OF EFFICIENCY IN CONSTRUCTION

Moscow BUKHGALTERSKIY UCHET in Russian No 3, Mar 82 (signed to press 10 Mar 82) pp 32-35

[Article by A. S. Narinskiy, professor and doctor of economic sciences, and L. F. Petukhova, lecturer at the Khabarovsk Institute of the National Economy: "Recording and Analyzing the Efficiency of Construction Work"]

[Text] The tasks of raising production efficiency and improving the quality of work determine the forms and methods of economic activity in all branches of production. "... The party's course toward raising efficiency and quality needs to be implemented with doubled and tripled energy. There is no alternative to that course," Comrade L. I. Brezhnev said at the November (1979) Plenum of the CPSU Central Committee.

A reliable system for recording and analyzing the processes of raising production efficiency has to be organized so that those processes can be managed. The principal shortcoming in this effort is in our opinion the absence of systematic recordkeeping on the actual efficiency of construction and the orientation of such calculations predominantly toward potential efficiency. To determine production efficiency one needs to select specific indicators which can be used to plan the rise in the level of economic performance and to measure the results achieved.

Although often the terms efficiency "indicator" and "criterion" are confused, since they are related to one another in their content, they do differ essentially in their purpose. Whereas an indicator of efficiency is a method of measuring processes of the same kind, only the one most important or summary indicator, the one used as the basis for solving the problem that has been set or for comparative evaluation of the performance of different enterprises or subdivisions, can be a criterion.

Creating a single efficiency indicator simplifies the taking of managerial decisions on the basis of an unambiguous representation of the processes and phenomena being studied. But as a practical matter it is not possible to propose an indicator so universal that it can reflect all the great diversity of processes determining the efficiency of production. And that is why several complementary indicators have to be used to measure the efficiency of production, and the most important or summary indicator, one which is formed on the basis of the primary indicators, is designated as the criterion of efficiency.

The peculiarities of the sector, and the uniqueness of its product and its production process have to be taken as points of departure in selecting indicators of efficiency.

The product of capital construction are the buildings and structures erected, expanded and rebuilt and the completed installation of equipment. Construction projects are attached to the ground and make up an indivisible whole with it. There are two important circumstances related to these peculiarities: projects finished and delivered to clients are turned over to other enterprises and economic organizations as fixed capital; it is assumed that the construction product will be used over a lengthy period of time. For that reason meeting deadlines for activation of completed projects, on which the increase in the volume of production in other sectors of the economy and the output of products depends, has decisive importance to the performance of enterprises, especially to indicators of their production efficiency. The introduction of a new economic concept, the marketed output of construction, which is the value of construction and installation work on enterprises, projects and independent complexes prepared for output of products and delivered to clients, is related to this indicator (see: A. N. Kosygin, "An Important Stage in Improving the Planned Management of the Economy," KOMMUNIST, No 12, 1979, p 23).

Fulfilling the assignment for activation of projects can be described by using a set of several indicators: fulfillment of the plan for the marketed output of construction and the average construction time of projects completed and delivered as compared to the standard time allowed.

Figures on the marketed output of construction indicate the estimated cost of projects prepared for operation, and they are entered in the ledgers of production recordkeeping and in report forms. Matters are more complicated in checking adherence to the established (standard or planned) deadlines for activation of completed projects. This requires above all that figures on the standard and actual construction time in months be entered in the cost ledgers of the principal production operation (Ledger No 10 or the respective "computergrams"), where they are indicated on the lines set aside for each of those projects.

Table 1, in thousands of rubles

Indicator	Project Number 1	2	3	4	5	Total
Estimated project cost	1,240	680	1,450	420	2,180	5,970
Construction time in months						
Standard	15	10	20	8	20	--
Actual	20	8	18	10	14	--
Product of the estimated cost and the construction time						
Standard	18,600	6,800	29,000	3,360	43,600	101,360
Actual	24,800	5,440	26,100	4,200	30,520	91,060

The dates of commencement and completion of work, confirmed by job orders for commencement of operation and documents on activation of completed projects, should be entered in the ledgers as the basis for determining the actual duration of construction work.

We propose that the average construction time of completed projects for the reporting period be calculated according to the example given in Table 1.

Since ahead-of-schedule activation of projects for production purposes and also delay of their activation create conditions for a respective increase or decrease of the output of products and the profit of enterprises which are the construction clients, the figures given above can be used to calculate the efficiency of activation of construction projects (Table 2).

Table 2

Indicator	Project Number 1	2	3	4	5	Average
Construction time in months						
Standard	15	10	20	8	20	17
Actual	20	8	18	10	14	15.3
Difference (+, -)	+5	-2	-2	+2	-6	-2.7
Increase or decrease						
Output, in thousands of rubles						
Daily plan	32,000	19,500	21,000	14,200	52,000	Total
Total departure from the output plan	-160,000	+39,000	+42,000	-28,400	+312,000	-188,400 +393,000
Profit						
Percentage plan	12	8	11	8	10	Total
Sum total of discrepancies, in thousands of rubles	-19,200	+3,120	+4,620	-2,292	+31,200	-21,492 +38,940

This computation is based on planning assignments for output and the average profit to be earned per day of operation of newly added capacities.

The average construction time of projects delivered cannot serve as an exhaustive description of fulfillment of the plan for activation of projects, since in that indicator the constructive and adverse departures from standards cancel one another out. It should be supplemented by data on the number and estimated cost of projects delivered ahead of schedule and behind schedule and on their relative share in the total volume of operations completed. These figures are contained in the table presented above. Moreover, to measure the efficiency of construction work we propose that the following indicators be used as well: profit from delivery of work items, the output-capital ratio, utilization of labor resources and labor productivity, and the quality of work items.

Use of profit as an indicator of production efficiency is made easier by the peculiarities of construction, which to a considerable degree eliminate division of work items into "profitable" and "unprofitable." The important thing is that the planned accumulation be included in exactly the same percentage in the estimated cost (i.e., release price) of the work items completed. In addition, reduction of the production cost of construction and installation work is planned and recorded for the construction organization as a whole, which in turn eliminates these differences between types of work items and the project where they are performed. The attachment of each construction project to the site of its future operation eliminates the factor of product shipment, and, by contrast with industrial activity, makes the time of delivery of the work items to the client coincide with their sale.

In evaluating production efficiency on the basis of the profit indicator it is advisable to eliminate from the sum total of profit from delivery of work items interest paid on bank loans covering unfinished construction in cases when that interest was collected by the bank at higher rates because of tardiness in repaying the loans.

The cutput-capital ratio is ordinarily computed as an indicator of the utilization of productive capital by dividing the volume of work items performed in the reporting period with the organization's own resources by the average amount of fixed and working capital employed. The volume of work items is given at their estimated cost and taking into account changes in remainders of work in process.

In computing the indicator of the return on fixed productive capital in construction difficulties arise which are related to the organizational peculiarities of the sector: various organizations which possess economic independence and have a separate balance sheet participate jointly in performance of the work items. The fixed capital whose return is to be computed is recorded on the various balance sheets. The most substantial portion of that capital belongs to construction machinery administrations and transportation organizations.

This means there is a need for recording the sum total of all the disparate capital assets participating in the production process; to that end we should determine the average value of fixed assets enlisted from outside and ensure that they are regularly reflected in records outside the balance sheet. This can be achieved without creating additional documentation or adding to the complexity of the existing documentation by relying exclusively on the bills of machinery administrations and transportation organizations and on the shift reports of machinery operators and truck drivers' trip logs appended to those bills. For the purpose of determining the average number of construction machines and trucks enlisted and of later assigning them reference prices per unit, we propose that the following computations be made: the total number of machine-shifts worked in the reporting period should be divided by the number of work shifts according to the production schedule in effect; the total number of ton-kilometers of trucking in the reporting period should be divided by the planned standard number of ton-kilometers established per shift of the machine's operation.

These computations should be done separately for types, models and makes of machines and trucks, and the number of each of them should be assigned a unit price according to the prices in effect. Aside from the information contained in bills from those furnishing services, the following reference data have to be available for this purpose: the number of work shifts in the reporting period according to the established production schedule, the planned number of ton-kilometers per machine-shift of each model (make) of truck, unit prices for each type, model and make of construction machines and trucks.

The recording of the enlisted fixed capital outside the balance sheet should be organized in the form of an annual report with cumulative totals.

In analyzing the general contractor's production efficiency it is advisable to use the indicator of the total return on own and enlisted fixed capital per ruble of their value on the basis of the estimated cost of the work items performed.

This will make it possible to summarize the results of work of all the machines used.

It is also important to constantly monitor the indicator of the total return on capital (relative to fixed capital) because the division of the functions of the supplier of services from the functions of the consumer of those services weakens the monitoring of the reliability of shift reports on the operation of machines. In addition, the localistic interests of machinery administrations make it difficult to combat padding of the number of machine-shifts worked. And that creates the conditions for a drop in the return on capital. That is why monitoring the return on capital will at the same time involve monitoring the reliability of figures on the use of machines. Rented property should also be included among enlisted fixed capital on the basis of the accounting figures on the capital of others, confirmed by documents, should also be included among enlisted fixed capital.

The method recommended for computing the return on capital is simple in and of itself and relies entirely on the existing documentation.

The summary indicator of the use of labor resources and of labor productivity should be computed by dividing normative net output by the average roster staff of the construction organization in the reporting period. This indicator synthesizes the influence of several interrelated factors: the relative share of the work force in the principal production operation in the roster work force of the construction organization, the percentage of appearances for work and output per worker. In analyzing an indicator like this one can determine the influence of each of these factors. Constant information on use of labor resources needs to be organized on the basis of these indicators as a part of statistical recordkeeping of the construction organization and included in reporting on fulfillment of the labor plan and the wages plan.

Among the indicators of the efficiency of construction the quality of the work performed has extremely great importance, though in the practical keeping of economic statistics these matters are still not paid the importance they deserve. The quality of work items is not planned, nor is it reflected in bookkeeping. A deterioration of the quality of work items might bring about a substantial reduction in the reliability of profit as an indicator of production efficiency.

The present procedure in which work items are paid for according to established stable prices regardless of quality has the result that in certain cases, when the work has not been done conscientiously, conditions may be created for an unjustified growth of profit because certain operations were omitted, others were simplified, and items were not completed. That is why profit indicators should in our view be unfailingly examined so as to take into account the quality of construction.

The following data should be used to describe the quality of construction: assessment of quality of work items delivered to clients according to a three-point system; the estimated cost of deficiencies recorded in the relevant documents appended to the document for transfer of construction projects after acceptance; and the sum total of losses from rejects.

The need for information on the quality of work performed can be satisfied by using various types of records: technical operation records (the log of work items) concerning the amount and quality of work done at specific projects on a three-point scale; records on work done by others in a grouping according to quality categories for the entire construction organization, internal records on rejects and especially of deficiencies recorded in the account "Rejects."

The indicators given above cannot serve as criteria of efficiency, which unfailingly should have an inherent unity and should be summary in their nature. In accordance with the peculiarities of planning and recording construction cost, profit from delivery of work items after deduction of increased (penalty) interest paid on credit to finance construction in process is most suitable as a sole criterion of production efficiency. At the same time a correction should be made if the quality of the work items delivered drops to the grade "satisfactory." For this purpose it is best to establish sound coefficients whereby profit from delivery of the work items would decrease as a function of the level of quality indicators referred to above.

The most radical solution to the problem of the relationship between the quality of work items and profit from their delivery would be to establish legislatively quality-dependent supplements to and discounts from the estimated cost of work items performed.

The effectiveness of production cost may be expressed not only by the absolute sum total of profit, but also by the ratio of profit from delivery of work items to the volume of such items (at estimated cost). Profitability, defined as the ratio of profit to the sum total of productive capital, an indicator adopted in industry, is unacceptable for the construction sector for two reasons: first, because capital is scattered among different balance sheets, as noted above, and second, because in construction accumulation is planned in percentages of estimated production cost of the planned amounts of work.

Another approach to solving this problem is also possible: computing the summary indicator of efficiency in the points established for evaluating the partial indicators. This requires establishing a point system and totaling them up for the construction organization. The value of every indicator could be estimated as a function of its relative importance. For example, for activation--from 0 to 100 points, for profit--from 0 to 50, for the quality grade of work items delivered--from 10 to 30, for deficiencies--from 5 to 20, for labor productivity--from 0 to 30, for return on capital invested--from 0 to 10. The specific scale of ratings ought to be established as a function of the level of every indicator for each branch of construction and on the basis of the conditions under which the work is done.

The summary estimate of the efficiency of construction work is important to comparing the performance of different construction organizations at different levels, for commensuration of the performance indicators of a single organization in different periods of time, and also for planning the assignment for raising production efficiency and for checking its performance.

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CONSTRUCTION

WAYS OF IMPROVING EFFICIENCY IN CONSTRUCTION DISCUSSED

Moscow VOPROSY EKONOMIKI in Russian No 5, May 82 (signed to press 27 Apr 82) pp 54-62

[Article by E. Golland and S. Finkel': "Improving Construction Efficiency"]

[Text] The technical level of construction in our country has improved substantially and its material and technical base has been strengthened over the last decade. At the same time unfavorable tendencies are being observed in construction that negatively affect its economic efficiency. The greatest negative factor is the insufficient growth in labor productivity. As a result construction times are 1.8 to 2 times greater than the standard level, and a growth in incompleted construction and an increase in the estimated cost is being noted.[1]

The economy of the USSR is being developed according to the laws for expanded socialistic means of production. "A steady growth in production necessitates constantly growing capital investments for the formation of new production capacities."[2] During the current decade, when the influx of labor resources will decline, ensuring that the growing volume of capital investments will be put to use without increasing the number of workers will become the main goal.

On the basis of an analysis of the annual rates of growth for labor productivity in construction and industry over 30 years (from 1951 through 1980) four periods can be singled out. Such a division into periods was caused by the dependency of the rates of labor productivity on the technological reorganization in construction production during these years which was associated with adopting and categorizing prefabricated reinforced concrete.

In 1951-53 a reduction from 109.9 percent to 104.3 percent in the annual rates of growth for labor productivity in construction is observed with a lag of 1.4 points behind labor productivity in industry on the average for the period.

1According to an estimate by academician T. Khachaturov, the increase in the cost of construction in comparison with the initial estimate of the cost is reaching 50 to 100 percent (VOPROSY EKONOMIKI No 7, 1979, p 129).

2T. S. Khachaturov, "Intensification and Efficiency Under the Conditions of Developing Socialism." Izdatel'stvo "Nauka", 1978, p 227.

Table 1

	1951-1953	1954-1960	1961-1965	1966-1980
Industry......	108.1	107.1	104.7	102.7
Construction*	106.7	109.5	105.7	100.9

*Labor productivity in construction excluding construction-repair organizations.

Beginning with 1954 a substantial reorganization took place in the construction industry associated with the adoption of prefabricated reinforced concrete which created the preconditions for accelerating the rates of labor productivity and surpassing their growth compared to industry. At this stage the rates of growth for labor productivity in construction exceeded analogous indicators in industry by 2.4 points.

From 1961 a decline in the effect of prefabricated reinforced concrete on the intensification of construction production is observed. At this time a reduction occurred in the annual rates of growth in comparison with the preceding period but, on the average, the rates of growth for labor productivity in construction surpassed the average annual rates of growth in industry for the years from 1961-1965.

Since 1966 the rates of growth for labor productivity in construction have tended to steadily decline and lag behind analogous indicators in industry. It would seem that the renovation of fixed assets, which was accomplished at more rapid rates in construction than in other sectors of the national economy, could have prevented the decline in the rates of growth for labor productivity (in 1980 the fixed assets in construction grew by a factor of 2.6 in comparison with 1970; for the same time it was by a factor of 2.2 for industry, 2.3 for agriculture and 2 for transport.) However, this did not occur. In our view the increase in fixed assets for the given period was caused by an extensive growth in the technical base of construction. The chief technological factor that stimulated the growth in labor productivity from 1954 to 1966 was the expanded use of prefabricated reinforced concrete and on the basis of it an improvement in the degree of standardization for construction elements, in the proportion of factory prepared products, and in the level of prefabrication at the construction site.

From the moment that the CPSU Central Committee and USSR Council of Ministers decree on the production of prefabricated reinforced concrete was approved its output increased by a factor of more than 20 and exceeded the level in the USA, France and FRG combined. The growth in the technical and economic indicators declines to the degree that the sector is saturated with prefabricated reinforced concrete components and, at the present time, emphasizing the further expansion of demand for prefabricated reinforced concrete is in conflict with the requirements for scientific and technical progress. At present the tendency of prefabricated reinforced concrete enclosure components for buildings and structures to become heavier is manifesting itself which leads to an increase in the weight of load-bearing components and, consequently, to an increase in material consumption--most of all for metal consumption in construction.* The USSR Minister of Construction, G. Karavayev, writes: "Over the span of the sixth

*See EKONOMICHESKAYA GAZETA No 7, 1981, p 7; V. Tolpygin. "Technical Progress in Construction Production."

to ninth five-year plans the primary precondition for growth in labor productivity in the sector was an increase in the volume of usage of components made from prefabricated reinforced concrete and an increase in the relative proportion of completely prefabricated construction. At present this possibility is almost exhausted. Expenditures for prefabricated reinforced concrete per 1 million rubles of construction and installation work is almost not increasing. The relative proportion of completely prefabricated construction has reached a high level and therefore the effect of the prefabrication factor on the growth of labor productivity is also coming to an end. It should be frankly stated that at the existing level at which builders are equipped with machines and provided with new materials that reduce labor consumption it is impossible to provide a growth in output of more than 2 to 3 percent per year. The extensive use of new advanced components could become a source of further growth for labor productivity...."*

One of the indicators of the intensification of social production is the coefficient of the level of technology which is calculated on the basis of a production function. It makes it possible to fix the influence of the totality of production factors. The results of calculations of productivity indicators, the capital-labor ratio, the yield on capital and the level of technology are presented in Table 2 (see next page).

Labor productivity is calculated as the relationship of the total amount of construction and installation work (SMR) that is completed by the contract and cost accounting methods to the number of workers that are engaged in construction and installation work, taking into consideration capital repairs. The relative proportion of capital repairs that are carried out by the cost accounting method of the total amount of SMR is determined in a manner similar to the relative proportion of capital repairs that are carried out by the contract method. The capital-labor ratio is calculated as the relationship of the annual cost of fixed production assets for construction to the average annual number of workers engaged in construction and installation work.

Numbered among the fixed production assets for the "construction" sector are funds that are used for construction and installation work and capital repairs and also production funds of other sectors that are calculated on the balance sheet of construction organizations' basic activities. The latter portion of funds is not associated with completing construction, installation and repair work.

The fixed production assets that are for construction purposes are determined according to the "USSR National Economy" handbooks for the corresponding years where indicators were taken for the "construction" sector and multiplied by a coefficient of 0.8. However, the derived conditionality does not distort the tendency of the phenomena being examined. The level of technology is calculated as the effect of labor productivity on the yield on capital. The indicator for the amount of fixed production assets that are associated with construction, installation and repair for all "construction" is calculated in accordance with the distribution of workers that are engaged in construction according to the types of production: about 80 percent in construction, installation and subsidiary

*KOMMUNIST No 16, 1980, p 65.

Table 2
Primary Economic Indicators in Construction

	Fixed production assets (in billions of rubles)	Total volume of SMR [Construction and Installation Work] (in billions of rubles)	Average annual number of people engaged in SMR (in thousands of people)	Rates of growth (in %): Fixed production assets	Rates of growth (in %): Total volume of SMR	Rates of growth (in %): Number of workers	Labor productivity (in rubles/person)	Capital-labor ratio (in rubles/person)	Yield on capital (in rubles/rubles)	Level of technology	Rates of growth (in %): Labor productivity	Rates of growth (in %): Capital-labor ratio	Rates of growth (in %): Yield on capital	Rates of growth (in %): Level of technology
1965	9.6	37.1	5,685				6,526	1,689	3.86	25,190				
1970	17.6	53.7	6,994	183.3	144.7	123	7,678	2,516	3.05	23,418	117.7	149.0	79	93
1971	19	58.6	7,383	108.0	109.1	105.6	7,937	2,573	3.08	24,446	103.4	102.3	101	104.4
1972	21.5	62.3	7,640	113.2	106.3	103.5	8,154	2,814	2.90	23,647	102.7	109.4	94.2	96.7
1973	23.6	65.0	7,630	109.8	104.3	99.9	8,519	3,093	2.75	23,427	104.4	109.9	94.8	99.1
1974	25.9	69.3	7,793	109.7	106.6	102.1	8,965	3,323	2.68	24,026	105.2	107.4	97.5	102.6
1975	28	74	7,930	108.1	106.8	101.8	9,331	3,531	2.64	24,634	104.1	106.3	98.5	102.5
1976	31.2	76	7,999	111.4	102.7	100.9	9,501	3,900	2.44	23,182	101.8	110.5	92.4	94.1
1977	34.4	78.8	8,052	110.3	103.6	100.7	9,832	4,272	2.29	22,515	103.5	109.5	93.9	97.1
1978	38.4	80.2	8,119	111.6	101.8	100.8	9,878	4,730	2.09	20,645	100.5	110.7	91.3	91.7
1979	41.6	81.9	8,150	108.3	102.1	100.4	10,049	5,104	1.97	19,797	101.7	107.9	94.3	95.9
1980	44.0	82.2	8,174	105.9	100.4	100.3	10,087	5,392	1.87	18,769	99.9	105.4	94.9	94.8

Calculated according to the handbooks: "The USSR National Economy in 1977" Izdatel'stvo "Statistika" 1978 p 364; "The USSR National Economy in 1979" Izdatel'stvo "Statistika", 1980 p 377,388,54; "The National Economy over 60 years" Izdatel'stvo "Statistika" p 449; "The USSR National Economy in 1980", pages 49, 347, 351.

production and approximately 20 percent in service and similar sectors.

An analysis of Table 2 shows that labor productivity in construction grew by a facotr of 1.5 over 16 years, the capital-labor ratio for one worker engaged in construction and installation work increased by a factor of 3.2 and the yield on capital declined. An increase in the output-capital ratio was one of the consequences during the particular period with the intensive development of the sector and the accelerated substitution of machines for manual labor. In this instance a growth in the output-capital ratio for labor that exceeds its productivity is inevitable. However, an increase in funds and a transition to another technological base creates the preconditions for accelerating the rates of growth for labor productivity. From 1965 to 1980 a decline took place in both the absolute growth of labor productivity and in the rates that it increased. The decline in the funds' effectiveness was accompanied by a drop in the level of technology by a factor of 1.3.

A drop in the level of technology is one of the chief factors for the decline in the growth of labor productivity. The growth in the capital-labor ratio for construction workers has substantially surpassed the growth in the level of technology and labor productivity in recent years. Nonetheless, the capital-labor ratio level for workers that are engaged in construction and installation work is still insufficient and it is substantially lower than the capital-labor ratio for industrial workers. (See Table 3).

Table 3

Sectors	1965	1970	1975	1976	1977	1979	1980
Industry*	6,872	8,071	11,305	11,949	12,621	14,083	14,936
Construction	1,689	2,516	3,531	3,900	4,272	5,104	5,382

*The capital-labor ratio for workers that are engaged in industry is calculated as the relationship of industry's fixed production assets to the average annual number of industrial and production personnel.

From table 3 it is evident that the capital-labor ratio for industrial and production personnel in 1965 exceeded the capital-labor ratio for construction workers by a factor of 4; in 1980 the substantial growth in construction's fixed assets reduced this correlation to a facotr of 2.8, but despite these positive improvements the construction industry has still not secured the highly effective funds that are necessary. An increase in the amount of funds has still not led to a growth in the level of technology in construction.

Accelerating the scientific and technological progress depends in many ways on the adoption of advanced technological processes, and an improvement in equipment, materials and devices. At the same time, of the new types of machines, equipment, apparatuses and devices that are intended for various sectors of industry the relative proportion of technical innovations that were created in the construction materials industry occupies one of the last places.

Over the span of the eighth to tenth five-year plans the relative proportion of new labor means in the construction industry amounted to just one percent. As a result many enterprises are characterized by a high level of heavy manual labor. For example, 35 to 40 percent of the workers at enterprises in the Ministry of Construction Materials in Moldavia were engaged in manual labor.

The level of scientific potential in construction, as in any other sector, depends on expenditures for NIP [scientific research work]. At present the relative proportion of scientific workers in the construction materials industry is one of the lowest.

Table 4*

	1965	1970	1975	1977	1980
Construction Materials........	4.1	4.0	4.0	3.9	3.6
Capital Investments...........	5.0	6.0	4.8	4.8	4.0
Number of Scientific Workers..	1.8	1.7	1.3	--	--

*As a percentage of the total volume of industrial production.

As is evident from the table all indicators are tending to decline; along with this the relative proportion of the number of scientific workers that serve the construction materials industry declined at greater rates than the relative proportion of its products against the total volume of industrial production.

The construction materials industry and other sectors that produce them lag behind other industrially developed countries in the output of up-to-date components (aluminum, glued, wood, and polymer components, those made from high strength metals and others) while at the same time surpassing them in the amount of prefabricated reinforced concrete used by a factor of 5 to 7. This is, in our view, one of the reasons for the lag in labor productivity and for the increase in the length of time for construction. At the same time our country occupies a leading position in the world in the production of steel and rolled metal and stocks of wood which makes it possible to organize the production of up-to-date components from them in the amounts needed by capital construction.

An increase in the efficiency of the construction complex requires a fundamental change in construction technology and that the construction complex be saturated with new technological systems and equipped with the appropriate technology along with organizational measures.

At the present time a basic principle in designing and erecting buildings and structures is oriented towards using overhead cranes to transfer cargo. The load-lifting capacity of an overhead crane is determined by the maximum weight of a unit of equipment almost irrespective of the frequency of its transfer. With an increase in the individual power of equipment is weight grows and the load on a building's framework increases which leads to a growth in the sizes and mass of columns, the beams under the crane and the footings. As a result the load from the effect of the crane's gantry reaches 65 to 90 percent while the buildings' slabs are only 10 to 35 percent. It should also be noted that the use of overhead cranes (originating with the conditions under which they are used) leads to an increase in the size of buildings by 35 to 40 percent, irrespective of the dimensions of the equipment that is installed and produced.

Mass production of ground type means of transportation-gantry, semi-gantry and boom cranes, crane-stackers, and conveyor and monorail types of technology-will make it possible to abandon the use of overhead cranes which will change the approach to constructing buildings. Separate structural approaches for the construction and technological sections of a future enterprise will become a chief principle.

Freeing the frames of buildings from crane loads leads to a reduction in structural bulk and reduces the loads, mass and weight of a building's elements. The possibility emerges of more fully utilizing the effect of lightweight components, shaped sheets, three layer and monopanels, glued wooden components, etc.

Reducing the mass of buildings and structures by means of using lightweight components that are completely prepared at the factory provides a substantial reduction in labor consumption during erection, in the estimated cost of construction, in the specific capital investments and in the length of construction.

A solution to the problem of producing lightweight building components is linked with the use of the most up-to-date materials: metal load-bearing components from economical shapes of rolled metal (hollow rolled metal, cables, wide shelf beams, high strength, thermally treated, and low alloy rolled metal and rolled metal protected by coverings); metal enclosure components from shaped steel or aluminum sheets with light polymer insulation (foam plastic, polyurethane, slag cotton slabs). The use of aluminum load-bearing and enclosure components from glued wood, glued plywood, and polymer materials and components using building materials made from the wastes of local industry, including pneumatic ones with or without a frame, are economical in a number of cases.

Native experience in the use of lightweight components which has been accumulated over the past years has shown their high level of effectiveness. compatibility and ability to be used in a majority of cases during construction of industrial and agricultural buildings that are intended for production purposes and civil construction structures.

The use of load-bearing metal "structure" type components in hollow shapes with lightweight "sandwich" enclosure panels and monopanels for the roof have made it possible to obtain substantially higher economic and operational indicators in comparison with traditional components from prefabricated reinforced concrete which is evident from the report data during construction of an industrial construction components combine in Krasnoyarsk.

A small increase in the cost of materials occurs chiefly for the following reasons. The elements of the "structure" component are made from common carbon steel. The use of low alloy or thermally strengthened steel makes it possible to reduce the consumption of rolled metal by 25 to 30 percent. The calculations for the reinforced concrete columns were done by starting with the assumption that reinforced concrete panels and slabs with girders are used whose weight was overstated by approximately 30 to 35 percent and the consumption of reinforcing by 10 to 15 percent. The thickness of the shaped floors amounts to 1.9 mm instead of the 0.6 to 0.7 mm required. The extra margin of strength in the "structure" components that was used in the calculations was overstated by a factor of 1.5 (which is confirmed by tests). If one assumes that all of the factors indicated are made to correspond to those that are required then, in our estimate, direct expenditures will be reduced by ?3,000 to 24,000 rubles, that is 28 to 30 percent lower than with the use of traditional reinforced concrete components.

Table 5

Primary Indicators for 100 Square Meters of Production Area

	Prefabricated Reinforced Concrete	"Structure", "Sandwich", Monopanels
Duration of Work (in days).............	5.36	1.64
Labor Expenses (in man/days)...........	166.6	72.8
Direct Expenses (in rubles)............	33,720	34,865
Including:		
Materials..........................	32,234	34,279
Basic wages........................	930	409
Overhead Expenses depending on the labor consumption for the work (in rubles)...	100	43.7

An analysis of the construction of shops at a number of metallurgical enterprises (a wide shelf blooming mill at the Nizhne-Tagil'skiy Metallurgical Plant, blast furnace No 9 at the Krivorozhstal" plant, oxygen converting shops at the Zapadno-Sibirskiy and Novolipetskiy plants and at Azobstal', a "2000" mill at the Cherepovets plant) has shown that with a weight of 20 to 25 kilograms for 1 square meter of the three-layer panel having polyurethane insulation, and 40 to 60 kilograms for the roof panel the total weight of the building was reduced by a factor of 4 to 10, and the length of construction by a factor of 1.5 to 2 in comparison with keramzit concrete. According to academician N. Mel'nikov's data the use of aluminum load-bearing and enclosure components, under the construction conditions at Chukotka, Mirnyy, Dikson and other regions of the Far North, reduces the mass of buildings by a factor of 20, the number of load transfers by a factor of 10 to 15, labor consumption by a factor of 5, the length of construction by a factor of 4 and the estimated cost of building 1 square meter of production area by a factor of 2.*

The construction of agricultural, civil and industrial buildings and structures from glued wood is being extensively developed at the present time. In agricultural construction these are chicken coops, cow barns, warehouses for mineral fertilizers, sheds for agricultural machinery and others; in civil construction--concert halls, light athletics arenas, swimming pools, markets, etc. A comparison of the construction indicators for light athletic arenas in Minsk, Gomel' and Uruch'ye, calf barns in Lithuanian SSR, and mineral fertilizer warehouses in

*See N. P. Mel'nikov, "Economizing Metal, The Gain Over Time (EKO No 9, 1980, p 11).

Belorussia testify that the use of glued wood components reduces the weight of walls, frames, and floor and roof slabs by a factor of 2 to 6 at various structures in agricultural and civil construction.

The economic effectiveness of glued wood components (KDK) is especially high when erecting buildings and structures with large bays. The erection of two light athletics arenas with 49 meter bays in Minsk and Gomel' has shown that the consumption of materials was reduced and the cost of construction correspondingly lowered in comparison with a similar sports arena in Uruch'ye (BSSR) which was made from metal components. The use of KDK when erecting buildings and structures that have aggressive agents (mineral fertilizer warehouses, production shops with chemical technology and others) increases their longevity by a factor of 4 to 5 in comparison with reinforced concrete components.

The use of all types of lightweight components requires a fundamental reconstruction of the technology for construction production. The formation of a technological and organizational production line is needed that would include the mechanized process and the process of preparing components at the factory and all the complementary parts, specialized transport, warehousing, storage and installation. The propagation of new technological systems in construction which are based on the use of lightened components that are completely prepared at the factory gives rise to the necessity of forming new subsectors in the construction industry - shaped floor slab plants, enterprises for producing metal components, shops and individual enterprises for turning out KDK and air bearing components-and of supplying them with resources. These are chiefly thin steel sheets with a thickness of 0.6 to 1.2 mm, low alloyed and thermally strengthened steel, coniferous wood, glues, paints, etc. Even with construction saturated to the maximum with the new components the demand on resources will not be excessive.

In our opinion the use of structure and enclosure panels for 50 percent of the area that is constructed when erecting buildings and structures in industry requires 11 to 12 percent of the amount of rolled metal that is expected to be turned out in 1985. Along with this the proportion of thin galvanized sheets will increase substantially, the production of which should be developed by ferrous metallurgy.

To build 50 percent of the agricultural production space and civil construction structures from wood components requires that coniferous wood be supplied in amounts that will not exceed 3 to 4 percent of all the wood that is being manufactured at the present time for industry.

Replacing traditional reinforced concrete and wood products will lead to a savings of metal and wood so that the total amount of these types of products that are used will not increase. The basic requirement of the sectors that supply construction is an improvement in the quality of a product that is being manufactured. For this it is necessary that the production of thin sheets, sheets with protective coverings, low alloy steel and thermally strengthened steel in ferrous metallurgy, and special stocks of wood in the logging industry be increased and that the quality of glues and paints be improved in the chemical industry.

Originating with the experience in building plants that make metal components, wall "sandwich panels" and monopanels, components from glued wood, and shops and sections for producing glues, paints and other lightweight components the capital investment required to form new capacities was determined which would amount to no more than 3 to 4 percent of the capital investments that were utilized in 1980.

The use of lightweight components will prove to have a significant effect on solving transportation problems. Up to the present time the amount of hauling involved in just mineral construction materials reached one-third billion tons or 30 percent of all shipping.* More than one fourth of the cargo hauled on railroads is for construction purposes and it reaches more than 60 percent on rivers. Along with this the amount of cargo being hauled for construction purposes is growing faster than the amount of all freight. The proportion of transportation expenses in the cost of a construction product is about 40 percent for the construction materials industry as a whole and it is even higher for wall materials.

Table 6

	Relative Proportion of Cargo Shipped by Railroad Transport	Relative Proportion of Cargo Shipped by River Transport
1965...........	23.7	40.1
1970...........	23.8	50.6
1975...........	26.1	59.1
1980...........	25.7	66.5

Based on the handbooks "The USSR National Economy in 1979," Izdatel'stvo "Statistika" 1980 pp 325,328; "The USSR National Economy in 1980," Izdatel'stvo "Finansy i statistika" 1981, pp 296, 302.

During the 10th Five-Year Plan rail transport reduced the growing shipping indicators but even with this the relative proportion of construction cargo hauled increased. If industry continues to turn out materials having the existing technical characteristics then, considering the rates of growth for capital construction in the country, the transportation of construction materials will become a difficult problem for transport to solve. A reduction in the amount of cargo hauled will in turn prove to have an effect on reducing the cost of construction materials. Thus, freeing substantial labor resources in the area of loading, unloading and transportation work depends on reducing the mass of buildings and structures.

The development of new principles and technology for designing buildings and structures, the most up-to-date components and materials, the construction of plants for producing them and lastly, the development of construction technology,

*Railroad, river and sea transport are what are meant.

the basis of which could be the highly accurate installation of structural components that are completely prepared by the factory, will substantially improve technical construction in the USSR.

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METALWORKING EQUIPMENT

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PROBLEMS IN INDUSTRIAL ROBOTICS TECHNOLOGY

Moscow VESTNIK MASHINOSTROYENIYE in Russian No 8, Aug 81 (signed to press 31 Jul 81) pp 3-5

[Article by Ye. I. Yurevich, doctor of technical sciences: "Problems of Unification and Standardization in Industrial Robotics"]

[Text] Through exploitation of advances in science and technology: develop the production and insure the extensive application of automatic manipulators (industrial robots) and integrated automatic control systems incorporating microprocessors and microcomputers, build automated shops and plants....

(Basic Directions for the Economic and Social Development of the USSR during the Years 1981-1985 and for the Period Extending to 1990)

The future immediately ahead will see industrial robots and manipulators become the most commonly employed and universal means of integrated automation of all spheres of the national economy, including machine building, mining, metallurgy, agriculture, construction, transportation, services etc. Today industrial robots and manipulators are employed in machine building primarily to attend production equipment independently to perform a number of operations (welding, assembly, painting, testing, control, transport).

"Basic Directions for the Economic and Social Development of the USSR during the years 1981-1985 and for the Period Extending to 1990" provides for further development of the production and insuring extensive application of this promising new means of integrated automation of production. According to branch estimates, the requirement for the simplest industrial robots with program control and manipulators with manual and automated control alone is calculated to run into the many tens of thousands. The number of types of these machines required already is many tens, a figure which in the immediate future will number in the hundreds. Timely and full unification and standardization of both the robots, manipulators and their components themselves and of standard robotized production systems therefore constitutes one of the most important and urgent problems in the field of robotics.

Work in this area in this country has from the very beginning been based upon Gosstandart SSSR's [USSR Council of Ministers State Committee on Standards] unified program for full standardization of industrial robots. According to this program, the end of the Eleventh Five-Year Plan is to have seen the preparation of nine GOSTy [all-Union state standards--TR] [five for industrial robots: terms and definitions (1980); classification (1981); basic indicators (1981); type-size series by lifting capacity (1981) and safety rules (1982) and four for program-control devices: general specifications (1983), noise stability, general requirements (1983), programming and coding methods (1980) and symbols and designations (1982)] and some 50 other normative technical documents [among them a set of directives concerning methods (1980-1982); sets of branch normative technical documents (1981-1985), a set of specifications (1980-1983) and others]. The most important GOSTy on terminology and classification have already been prepared (by OKBTK LPI) [Special Design Bureau of Applied Cybernetics, Leningrad Polytechnical Institute imeni M. I. Kalinin].

The term "industrial robot" has been defined here as a programmable automatic machine which can be employed in a production process to perform motor functions similar to those performed by a human being in moving objects of production and/or production equipment or devices. The presence of one or more manipulators is a distinguishing characteristic of an industrial robot.

Let us note in this connection that the term "automatic manipulator," frequently used in place of the term "industrial robot," is obviously to be considered a synonym only in the case of robots having only one manipulator. As far, too, as the term "automatic manipulator with program control," a term extensively employed in our domestic literature, is concerned, it has an even narrower meaning, since it refers only to industrial robots with wired-in programs, that is, to first-generation robots (without sensitization and adaptation).

Because work on the development and fabrication of industrial robots and manipulators in our country has been organized in a timely manner by the USSR State Committee on Science and Technology into an integrated program, it has been possible from the very beginning to base their development upon the principle of interbranch unification. On the basis of an analysis of requirements undertaken in the course of the Ninth Five-Year Plan by the major machine-building branches, OKBTK LPI, as the primary organization in the field of industrial robots, jointly with primary branch institutes of design and technology has worked out interbranch series of basic unified components, drives and control devices primarily, prepared technical assignments for developing them and coordinated these assignments with the branches involved.

Minstankoprom's [Ministry of the Machine-Tool and Tool Manufacturing Industry] VNIIGidroprivod [All-Union Scientific Research Institute of Hydraulic Equipment] (Khar'kov) is carrying out work on unified hydraulic and pneumatic equipment. Minpribor's [Ministry of Instrument Manufcaturing, Automation Equipment and Control Systems] LEMZ [Leningrad Electrical Equipment Plant] is working on unified control devices jointly with OKBTK LPI.

The hydraulic and pneumatic equipment which has been developed for the most part measures up to the requirements of industrial robot and manipulator developers. What we are talking about here runs to some 200 individually designated peices of hydraulic equipment, to include miniaturized and modular equipment, and more than 50 different types of pneumatic equipment (linear and rotary motors, valves, distributors, dampers, hydraulic stations, etc.) from which a variety of closed circuit (servo) and open-circuit drives are assembled.

Ahead of Minstankoprom in the Eleventh Five-Year Plan is the task of organizing the series production of all this equipment (some 50 per cent is now in series production), continuing efforts to improve its quality (the quality of its electrohydraulic servodrives in particular) and extending its product list (developing positional pneumatic drives, among other things).

As far as unified electric drives are concerned, we can see a certain amount of progress after a long period of lagging behind--the first series of 25-2200 W dc drives has now been developed. But neither the technical level, nor, especially, the product list of electric drives manufactured by Minelektrotekhprom [Ministry of the Electrical Equipment Industry] are today suiting the needs of industrial robot developers (there are no sets of servodrives, to include digital drives; their weight and dimensions are unsatisfactory and they cost too much).

The unified control devices for industrial robots with program control (cyclical, positional and loop) manufactured by Minpribor are, on the whole, good technically. But to the end of further improvement of reliability and reduction in cost, Eleventh Five-Year Plans call for a changeover to the next generation of components, to include microprocessors [1].

As these unified components go into series production they will be employed as well in the conversion of the models of industrial robots and manipulators the various branches have already developed, and this process is already under way.

The development of unified basic components for industrial robots was the first phase of the unification effort in the field of industrial robots. The next phase will be to make the transition from the unification of basic functional robot components to the unification of their structural components in the form of modules. This is to be taken to mean a transition to a fundamentally new way of designing and building robots and manipulators, to modular structures which will in the future make it easy to make numerous modifications of industrial robots and manipulators on the basis of the same structural components. This will offer the possibility in each specific instance of selecting the optimum degree of kinematic and program redundancy, cost and distribution of functions between a robot and the production equipment involved (to the possible extent of structurally integrating individual robot components with the equipment to be served). These modules should serve as a basis upon which to develop interbranch series of robots and manipulators, this in turn as a basis for developing branch series of these devices.

Studies indicate that approximately 10 pneumatic, 20 hydraulic and 15 electromechanical modules would be enough to build all the basic types of industrial robots required today. Let us draw up a rough list of unified structural modules involving the mechanics of industrial robots and manipulators [2]:

Module and level of complexity	*Module characteristics*
Monoblock (pneumatic, hydraulic, electromechanical), 1	Performs structural, drive and information functions for one (two) degrees of motion of a robot. Includes lower-level modules.
Drive module (pneumatic, hydraulic, electromechanical), 2	Performs structural and drive functions for one degree of motion. Robot design requires use of an information module and 4th- and 5th-level modules.

Module and level of complexity	*Module characteristics*
Servo module (pneumatic, hydraulic, electromechanical), 3	Performs functions of a servomechanism
Equipment module, 3	Performs functions of drive control unit for 1st- and 2d-level modules
Information module, 3	Performs information functions.
Mechanism, 4	Designed to transmit and convert motion.
Components (assembly, part)	The simplest nondrive mechanical or equipment components. Nondetachable parts of robot.

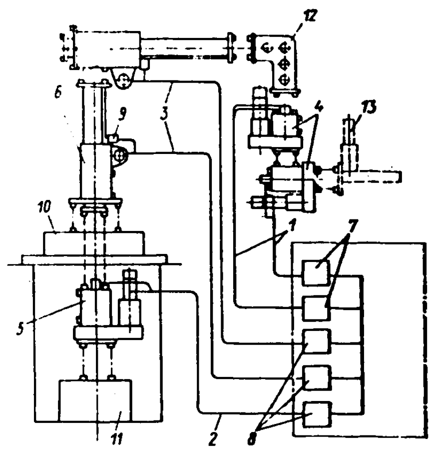

Figure 1. MP-12 modular electromechanical industrial robot, 20 kg load capacity: 1, 2,3 - rotation (Me-V-1, MeV-II) and translation (Me-II-II) monoblocks; 4,5,6 - rotation (Ie-B-1, Ie-V-II) and translation (Ie-II-II) servo units; 7, 8 - equipment modules (A-I, A-II); 9 - information module (A); 10 - base module (0); 11 - modular counterpoise device (Ur); 12 - modular connecting component (K); 13 - gripper.

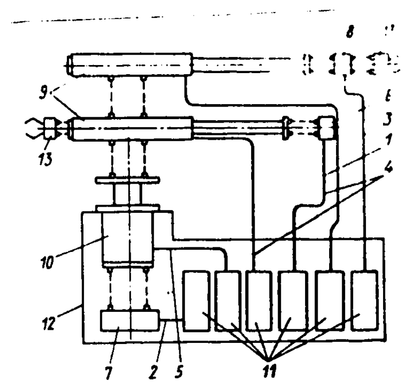

Figure 2. MP-11 modular pneumatic industrial robot, load capacity 0.2 kg: 1, 2, 3, 4, 5 - rotational (Mn-V-I, Mn--V-II), horizontal translational (Mn-Pr--I, Mn-Pr-II) and vertical translational (Mn-Pv-II) monoblocks; 6, 7, 8, 9, 10 -- rotational (Ip-V-I, Pp-V-II), horizontal translational (Ip-Pg-I, Ip-Pg-II) and vertical translational (Ip-Pv-II servo modules; 11 - equipment module (Ap); 12 - base module (0); 13 gripper.

We can enumerate in general terms the following advantages to be derived from the employment of series-produced, unified modules:

- sharp reductions (from two-three years to two-four months) in the periods of time required to develop, then to fabricate and introduce new models of industrial robots and manipulators since they will be assembled from proven series-produced components;
- the technical level, reliability most importantly, improves, while robot costs decrease;
- outlays for the introduction and operation of industrial robots and manipulators are reduced and their operation made simpler;
- the economic gain from a changeover to modular designs runs to at least 1.5 million rubles per thousand robots manufactured.

An analogous modular principle must now be realized in our robot control devices, as well as in the computer software employed in robot control systems. In addition to the advantages enumerated above, this will also solve the problem of providing not only the robots themselves, but robotized production systems as a whole (sections, lines, shops) with control systems. This will make it possible sharply to accelerate, simplify and reduce the cost of building these systems, which essentially is the ultimate objective of the application of robotics in branches of the national economy.

Building a system of modules for control devices will require the development and organization of series production on the part of Minelektronprom [Ministry of the Electronics Industry] of Minpribor's set of the necessary special microelectronic components and sensing equipment.

OKBTK LPI has developed a unified system of modules which will make it possible to solve a number of problems, to include that of group and adaptive control using conventional computers integrated into automated production control systems.

Work on the first modular industrial robots and modular control devices for them has already been begun in a number of branches. A basic model for a series of SM40Ts4300 modular hydraulic robots has now been developed, for example. Figure 1 is a diagram of the MP-12 modular electromechanical industrial robot, Figure 2 a diagram of the MP-11 robot, a modular version of MP-9c pneumatic robot. OKBTK LPI has now developed the first YeSM-02 modular industrial-robot positional control device.

As we can see, the problem in robotics does not reduce simply to building the robots themselves; the ultimate objective is to develop robotized production systems, these primarily for basic types of production processes. In addition to unification of the robots themselves, this will therefore also require unification of these systems themselves, including their standard components.

Timely preparation of a full set of normative documents for the field of robotics and consistent development of the modular principle in process of designing all robotics systems and components will lay a firm, scientifically based foundation upon which to base our own domestic robot industry and from which to proceed with a well-planned program of introducing industrial robots and manipulators in all branches of the national economy with the objective of fully automating production on an extensive scale and achieving an essential solution to the problem of labor resources.

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